NASA'S RODENT RESEARCH PROJECT ON ISS: VALIDATION OF A NEW PLATFORM FOR CONDUCTING BIOMEDICAL AND BASIC RESEARCH INTO THE CONSEQUENCES OF LONG DURATION HABITATION IN SPACE

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Rodent research has played a key role in advancing biomedical discoveries both on Earth and in space. The National Research Counsel's Decadal survey[(1)] emphasized the importance of expanding NASAs life sciences research to perform long duration, rodent experiments on the International Space Station (ISS). To accomplish this objective, flight hardware, operations, and science capabilities were developed at NASA ARC to support both commercial and government-sponsored rodent research.

Rodent Research-1 (RR-1) was the first mission in which animals were delivered and maintained in the ISS for a long duration mission in modified Animal Enclosure Module hardware. Both RR validation and commercial science objectives were pursued on the RR-1 mission. Adult female mice (20 total Flight, FLT) were launched Sept 21, 2014 in RR hardware within a Dragon Capsule (SpaceX4), then after 4 days in transit, were transferred for habitation on the ISS for 17 days (commercial) or 33 days (validation), when animals were euthanized and select tissues recovered on orbit. Various controls groups consisted of: 1) Basal mice from the same cohorts as FLT mice, but tissues were recovered at time of launch, 2) Vivarium (VIV) were housed in standard cages 3) Ground Controls (GC) were housed in flight hardware within an environmental chamber at Kennedy Space Center. The health and behavior of all mice on the ISS were monitored by video feed on a daily basis. Mice were euthanized by injection of Euthasol, then either fast frozen intact or dissected to preserve livers (fast frozen) and spleens (RNAlater). Samples were stored at ≤ -80˚C until their return to Earth for later analyses.

Hardware performed nominally throughout the mission and the planned in-flight science operations were completed successfully. FLT mice appeared generally more physically active on orbit than respective GC groups. After 33 days on the ISS, mean body weights of FLT mice did not differ from GC, with both groups showing a 6% rise compared to time of launch, while VIV mice showed an 8% rise over the same period. Importantly, there were no significant differences in body weights between groups at the end of 33 days on the ISS, providing an indication that the RR hardware supported the health of the mice both on Earth and in space. Based on the preliminary data obtained from the livers and spleens of mice after 17 days on the ISS, purified RNA was of high quality (RIN values of spleen: FLT=9.48 +0.40, GC=9.28 +0.44, n=5/group); therefore, RNA quality from samples retrieved on orbit was acceptable for even the most demanding transcriptomic analyses. In addition, liver enzyme activity levels (units/mg protein) of FLT mice (after 17d on ISS) and all control mice were similar in magnitude to samples that were optimally prepared by freezing in liquid nitrogen in the laboratory (enzymes analyzed included catalase, glutathione reductase and glyceraldehyde-3-phosphate dehydrogenase). Validation analyses still in progress include behavior and tissue biochemistries, as well as optimization of science return by post-flight recovery of tissues for biospecimen sharing and global expression analyses.

Together, these preliminary findings demonstrate new capability for supporting long duration rodent research on the ISS to achieve both basic science and biomedical objectives.

REFERENCE

[1] NRC Decadal Survey on Biological and Physical Sciences in Space, (2011) http://sites.nationalacademies.org/SSB/CompletedProjects/SSB_067720